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(54) PROCESS AND INSTALLATION FOR CONTINUOUSLY LOADING RADIO-ACTIVE OR TOXIC MATERIALS INTO CONTAINERS

(71) We, VEREINIGTE EDELSTAHLWERKE AKTIENGESELLSCHAFT and OSTERREICHISCHE STUDIENGESELLSCHAFT FUR ATOMENERGIE G.m.b.H. both Austrian Bodies Corporate of 1010 Wien, Elisabethstrasse 12, Austria and 1082 Wien, Lenaugasse 10, Austria respectively, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is a method of embedding radioactive or toxic wastes in a binder so that the wastes can be stored.

The use of nuclear fission as a source of energy brings problems of disposing of radioactive wastes; and toxic wastes present similar problems.

In particular, radioactive waste waters, which arise in neclear power stations in large amounts in the form of pre-concentrates from processing plants and purification plants, make exacting demands on safety in storage.

The customary form of storage in containers on the power station site entails considerable costs for screening, storage and supervision, and still does not represent a final solution of the problem. It is necessary to provide a final storage area remote from the power station site and which is largely safe from environmental influences.

Delivery from the site to such a storage area can in most cases only take place via the public roads or railways. Consequently it is effectively necessary that the packaged material be solidified to such an extent that escape of the stored material is reliably prevented during transport, and later in storage, even under the action of external force.

In association with nuclear power stations, it is therefor desired to have solidifying installations, and these should be as compact as possible.

Materials, such as cement and bitumen are suitable for solidifying radioactive waste of low to medium activity, and glass and metal are suitable for high activity. The embedding of material of low activity in bitumen offers particularly great advantages since, in the event of unforseen intrusions of water, the material thus solidified is leached to an extent which is smaller by orders of magnitude than that of waste materials bonded with cement.

The processes known hitherto for bitumenising radioactive residues are in the main based on mixing molten bitument with pre-concentrated thick solutions from evaporation plants and purification plants, the water simultaneously being evaporated off. Mechanical stirring devices, mixing devices or kneading devices are used for mixing the components and evaporating the water.

In our patent specification No. 1,414,073 we describe and claim another method of binding radioactive or toxic substances with a binder such as bitumen. In the described embodiment of that method, a radioactive or toxic effluent in liquid state is concentrated and then dried to a powder, and the powder is wiped into a collecting chamber having a heater and containing a liquid binder. It is possible to work under reduced pressure (i.e. under partial vacuum) according to Patent 1,414,073. When the collecting chamber is full of binder and powdered waste the supply of concentrate into the drier is interrupted and the collecting chamber is set aside to cool and is sealed. Claim 1 of our said specification reads

"A method of embedding a radioactive or toxic substance in a binder of lower specific gravity than the substance, comprising providing a binder in a liquid state and introducing the radioactive or toxic substance in a dehydrated particulate form into the binder by allowing it to fall into the binder under gravity to form a sediment

comprising the substance particles totally encapsulated by the binder."

It will be apparent that in the method described in our specification No. 1,414,073, it is necessary to switch off the installation when one collecting vessel has been filled and is to be exchanged for a new one. Moreover, when the installation is opened, the vacuum is released and a risk arises of contaminating the surroundings by airborne radioactive materials.

The present invention deals with these defects of our previously disclosed method of embedding a radioactive or toxic waste in a binder such as bitument. According to the present invention there is provided a process for embedding a solid radioactive or toxic substance in a binder of lower specific gravity than the substance, which comprises introducing the binder into a first storage vessel, and charging the substance in particulate form and under sub-atmospheric pressure at a charging station into the binder in liquid form so that the individual particles become encapsulated by the binder which is subsequently solidified, and in which process a second storage vessel is subjected to said subatmospheric pressure while said substance is charged to the first vessel and then when charging of the first vessel is complete it is removed from the charging station and replaced by the second vessel, subatmospheric pressure being maintained on both vessels while the first vessel is replaced by the second.

Thus the invention provides a process for continuously loading radioactive and/or toxic materials which are in the solid state, preferably in the dry or dried state, by sedimentation in a liquid binder, preferably bitumen, asphalts, tar or thermoplastics.

After the second storage vessel has been filled it is replaced by a third vessel which has been prepared for filling while the second was being filled.

In this process, it has proved expedient to introduce the binder at the same time as the radioactive or toxic substance is charged to the vessel. The binder here is advantageously fed in via spray nozzles.

The proposed process makes it possible to carry out the bitumenisation by loading dry or pre-dried radioactive wastes, such as, for example, ash or dehydrated salts in a continuous process directly into the packing container, for example drums, intended for the final storage. This obviates the need for a collecting container or filling container, in which the mixing of radioactive waste with bitumen takes place, upstream of the packing container. In addition to simplifying the method of working, this offers the great advantage that it is not necessary to carry out expensive cleaning work with organic solvents, if encrustations or formations of deposits should occur in the packing container. Furthermore, it is possible to change the drums in a short time by means of the arrangements described in the following text, so that the process can proceed continuously, that is to say without interruption or switching off of the component parts of the installation. Furthermore, there is a possibility, by appropriate measures, of fitting out an installation of this type for fully automatic operation under remote control.

For carrying out the process according to the invention, an installation is proposed which comprises a rotatable plate provided with receivers for the storage vessels, which receivers are equipped with floors which can be lowered and with heat insulation and heating devices, and rotatable to bring successive receivers from a second position where they are evacuated to a first position where they are charged with said radioactive or toxic waste, the plate being fitted with gaskets for sealing the receivers from the surrounding atmosphere to permit the maintenance of subatmospheric pressure on the receivers and on the storage vessels when in the receivers.

Preferably the installation includes also a drier for the liquid wastes, arranged to discharge dried wastes to a storage vessel when said storage vessel, in one of the receivers, is in said first position, which drier is connected to a vacuum pump through which in use of the installation said subatmospheric pressure is maintained.

It proves advantageous to provide the installation with a gasket which is dust-repellent, but permeable to gas, and which fills the free space above the rim of the container and prevents contamination of the outside of the container.

With advantage, the installation according to the invention possesses a mobile gasket which in the working position isolates the receiver, with respect to pressure, from the outer atmosphere whilst the container is changed.

Provision of a conveyor device proves expedient for loading the radioactive materials arising in a solid form.

The installation according to the invention is explained in more detail by reference to an illustrative embodiment:

Figure 1 diagrammatically shows the installation together with further parts of the plant. Figure 2 shows details of the pivoting receiver for the containers, Figure 3 shows a plan of the receiver for the containers and Figure 4 shows a variant of the receiver for the containers, which is also suitable for embedding other particulate solids, such as evaporation residues.

As shown in Figure 1, the aqueous concentrate which is produced in an

evaporation plant 1 of customary construction, is introduced, by means of the cencentrate feed pump 2, into the drier 3 which preferably can be a motor-driven thin film evaporator of known design. In the drier 3, the concentrate is dehydrated by evaporation, the resulting solids being in a free-flowing state. These solids drop directly into the packing container 4, located below, which contains a prepared layer of liquid bitumen 5, settle therein and form a close-packed sediment 6. After a certain time during which more solids are continuously sprinkled in and the bitumen layer is gradually filled up, or, as an alternative, continuously and simultaneously with the sprinkling in, further liquid bitumen is added by means of the bitumen feed pump 7, until finally the packing container 4 is entirely filled with a bitumen/solid mixture. The bitumen for this purpose is brought to the requisite process temperature in the bitumen preheater/container 8 with the heating coil 9. In the case of continuous bitumen feed, it can be useful for the process not to direct a sharp jet of bitumen into the packing container, for example a final storage drum, but instead a gentle spray which acts over an area. In this way it is possible to obtain partial wetting and enveloping even before the solid particles impinge on the surface of the bitumen. In this case, the outlet 10 of the bitumen feed line has the shape of an appropriate nozzle with a spray action. The exhaust vapours produced during drying are passed, by means of the vacuum pump 11, to the condenser 12 where they are precipitated. Dust particles carried over with the exhaust air are retained by the dust filter 13. The condensate from the condenser 12 represents only a fraction of the quantity which had been fed as effluent to the evaporation plant 1, and it can therefore be recycled back to the evaporation without a noticeable economic loss. In addition to exhausting the vapours, the vacuum pump 11 provides for a subatmospheric pressure in the installation, which prevents an egress of radioactive materials through leakage points.

The receiver 14 for the containers (storage vessels, e.g. drums) consists in the main of the circular plate 18 and the two receivers 15 and fulfils several tasks. In the first place it serves to position the container 4 which is being charged underneath the drier 3. Furthermore, it also maintains the container 4 at the operating temperature necessary for the process by means of insulation 16; in addition there is a heater device 17 so that, if necessary, heat can be put in to the liquid bitumen. Finally, the receiver for the containers also provides for evacuating the packing container 4, so that the embedding process can be carried out at any desired reduced pressure. Contamination of the outside of the contain r is reduced to a large extent (see Figure 2) by means of the gasket 23 which is dust-repellent but permeable to gas and fills the free space above the rim of the container. It is also possible, by means of an additional fitting, to blow superheated steam into the interspace between the packing container 4 and the receiver 15, so that egress of radioactive dust is prevented by the flow directed inwards from the outside. The receiver 14 for the containers, with its plate 18, is supported on a roller cage 20, so that it can rotate or pivot around the axis 19, as shown in Figure 3, the two fixed positions representing the end position which in the following text are designated as the working position and the change position.

Figure 3 shows the receiver 14 for the containers in plan. In the working position 32, the container 4 is located below the drier 3, and filling with bitumen and radioactive solids proceeds. In the opposite position, the change position 33, the filled container is exchanged for an empty container. Venting necessary for this purpose takes place via the valve 28. Preferably the exchange of containers is carried out downwards by lowering the floor 21 of the receiver for the containers by means of a vertically movable device 22. In principle, it is also possible to lift out the full container and to insert the empty container from above. In this case it is expedient to provide an opening which can be closed in the casing plate 29.

In the change position, the following preparations are made for the subsequent use of the empty container:

1. Exchange
2. Setting the operating pressure via valve 30
3. Preheating the container by means of the heating coil 17 which is surrounded by the insulation 16
4. Filling in of a first layer of liquid bitumen via the feed line 24.

During the exchange, through the open floor 21 of the receiver 15 in the change position 33, the mobile gasket 31 provides for a separation, with respect to pressure, of the receiver 15 in the working position 32 from the surrounding atmosphere, and the reduced pressure in the working position 32 is maintained. When the floor 21 is closed, reduced pressure is restored in the change position 33 via line 30, and the gasket 31 returns to its initial position.

The drier continues to run even whilst the receiver is turned. However, provision is made for interrupting the bitumen feed and stopping the bitumen feed pump 7 during rotation of the receiver. During this period,

the flap 25 also is closed in order to intercept the flow of solid particles from the drier. During this period, the reduced pressure in the drier 3 and in the downstream condenser 12 and exhaust air filter 13 is preserved, When the first container has been removed and a second container brought to the charging position, the quantity of solids which have collected in the meantime is sprinkled in all at once, after opening the flap 25, and the filling process continues normally. The upper part of the receiver 14 for the containers is separated from the surrounding space by the gaskets 26 and 27, which effects a pressure seal and also prevents egrss of radioactive dust. For maintenance work, decontamination of the space enclosed by the gaskets can be carried out by spraying either superheated steam or water or a solvent into said space. It is also possible to submerge the entire receiver for the containers under water.

It is possible to use this apparatus for embedding of radioactive ashes from combustion or of pulverulent or granulated residues arising in other processes. Figure 4 shows, in plan, a receiver 35 for the containers for the combined embedding of ashes from combustion and of aqueous concentrates, the installation also possessing, in addition to the components already described, a conveyor device 34 for granulated solids. This conveyor device 34, which can for example, be a conveyor screw, effects the transport from the place of production, for example the ash chamber of a combustion plant for combustible refuse, to the filling plant and, at the same time, effects metered feed-in. The receiver for the containers now has two filling positions, optionally the solids from aqueous concentrates being sprinkled in in the working position 36 in the manner already known and the ashes being sprinkled in in the working position 37. One change position 38 is adequate for both processes. This arrangement is distinguished by the advantage that a saving of space is achieved as compared with several individual installations and various necessary accessory parts, such as exhaust air filters, interior filters and the drum handling device only have to be provided singly.

When testing the process according to the invention, up to 60—75% by weight of solids were introduced into the bitumen. In this way, extensive utilisation of the capacity of the packing containers, and hence of the general storage capacity, is made possible. In the solidified state, the contents of the container form a practically homogeneous block which has a high dimensional stability even under extreme mechanical stress during transport or in storage.

Leaching experiments have shown that these bitumen mixtures, fully charged with salts, have a leaching resistance which is several orders of magnitude higher than that of wastes which are solidified with concrete.

Molten bitumen is suitable with particular advantage as the binder for the process according to the invention. Similar materials, however, such as molten asphalts, tar, thermoplastics, and also curable liquid binders such as synthetic resin components, bitumen emulsions and also cement slurry, can also be used after appropriate adaptation of the installation.

WHAT WE CLAIM IS:—

1. A process for embedding a solid radioactive or toxic substance in a binder of lower specific gravity than the substance, which comprises introducing the binder into a first storage vessel, and charging the substance in particulate form and under subatmospheric pressure at a charging station into the binder in liquid form so that the individual particles become encapsulated by the binder which is subsequently solidified, and in which process a second storage vessel is subjected to said subatmospheric pressure while said substance is chaged to the first vessel and then when charging of the first vessel is complete it is removed from the charging station and replaced by the second vessel, subatmospheric pressure being maintained on both vessels while the first vessel is replaced by the second.

2. A process according to claim 1, in which the binder is introduced to the first storage vessel in liquid form.

3. A process according to claim 2 in which the liquid binder is introduced to the storage vessel during charging of the vessel with said radioactive or toxic substance.

4. A process according to claim 3, in which the liquid binder is sprayed into the storage vessel.

5. A process according to claim 2, 3 or 4 in which the binder is bitumen pre-heated to melt it.

6. A process according to any preceding claim, in which a radioactive or toxic substance in liquid state is dried to a powder and fed from the drier into the storage vessel while exhaust gases are pumped from the drier thereby maintaining said subatmospheric pressure.

7. A process according to any preceding claim in which while the first vessel is being charged the second vessel is preheated and a layer of liquid binder is introduced to the second vessel.

8. A process according to claim 1,

substantially as hereinbefore described.

9. An installation for carrying out the process according to any preceding claim, which comprises a rotatable plate provided with receivers for the storage vessels, which receivers are equipped with floors which can be lowered and with heat insulation and heating devices, and rotatable to bring successive receivers from a second position where they are evacuated to a first position where they are charged with said radioactive or toxic waste, the plate being fitted with gaskets for sealing the receivers from the surrounding atmosphere to permit the maintenance of subatmospheric pressure on the receivers and on the storage vessels when in the receivers.

10. An installation according to claim 9 having a movable gasket arranged to isolate each receiver from the surrounding atmosphere, thereby maintaining said subatmospheric pressure on the receiver, when the vessel in said receiver is exchanged for another.

11. An installation according to claim 9 or 10, provided with a drier for said radioactive or toxic substance, which drier is arranged to discharge the dried substance to the receiver in said first position and is connected to a vacuum pump which in use of the installation removes exhaust gases from the drier and maintains said subatmospheric pressure.

12. An installation according to claim 9, constructed, arranged and adapted to operate substantially as herein described with reference to the accompanying drawings.

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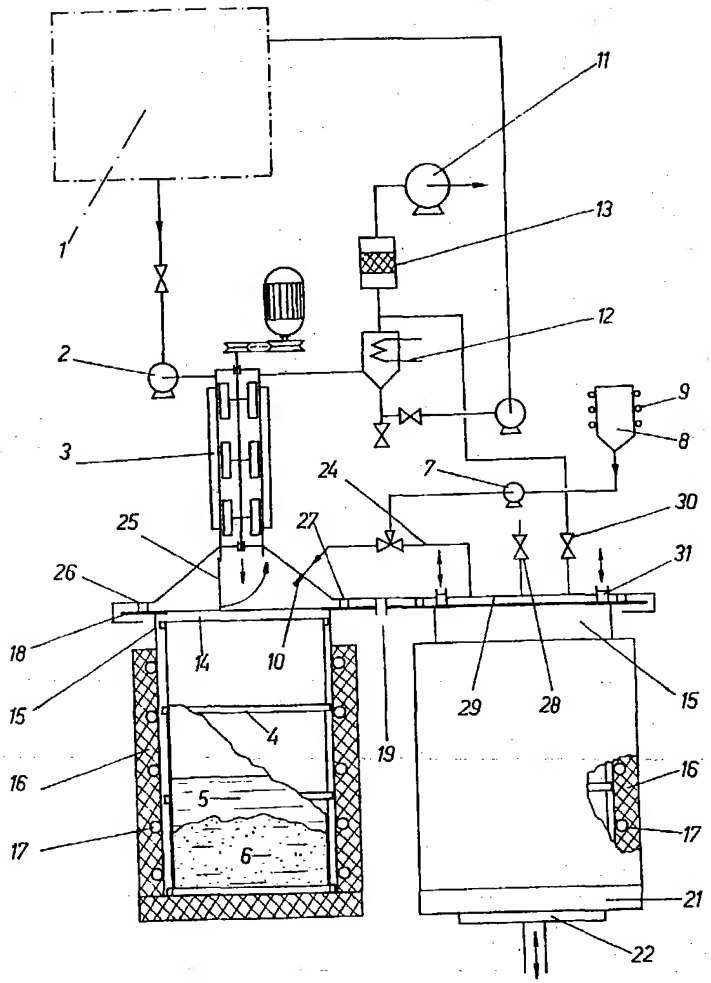
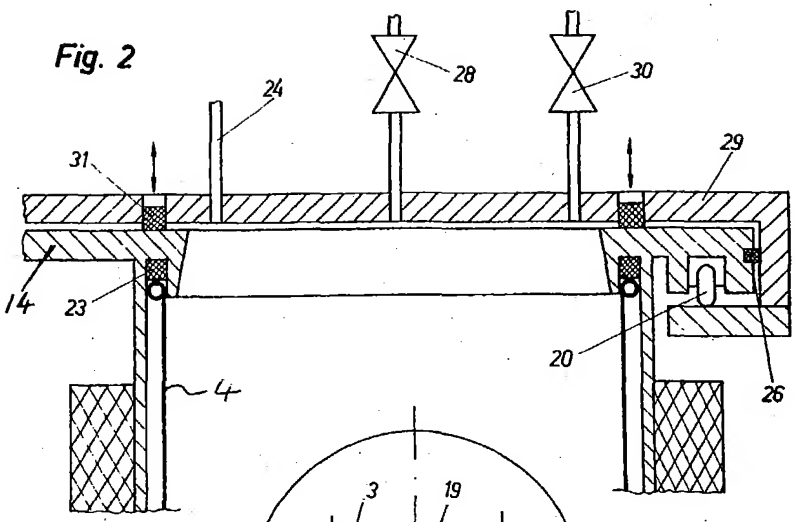
Sheet 1

Fig. 1



1510494 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 2

Fig. 2



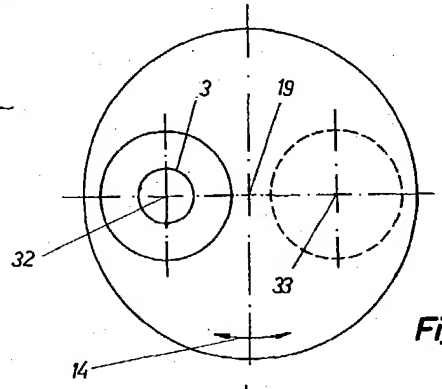


Fig. 3

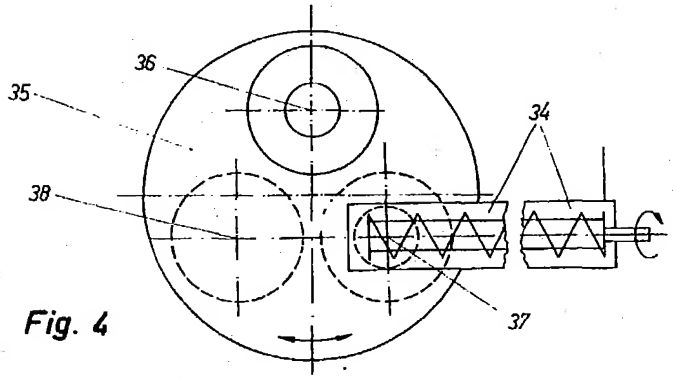


Fig. 4